Independent Applicability of Chemical and Biological Criteria/Standards and Effluent Toxicity Testing

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In 1985 the U.S. Environmental Protection Agency (EPA) advocated a two-part approach for water pollution control involving chemical concentration-based effluent limits for those parameters for which water quality criteria had been developed and toxicity test-based effluent limitations. The chemical-specific component was designed to prevent exceedances of water quality criteria values in ambient waters receiving point and non-point source discharges or runoff; the water quality criteria were, in large part, developed to be chronic-exposure, safe concentrations for sensitive aquatic organisms. The toxicity test component was designed to indicate potential toxicity effects associated with an activity, to account for the possible presence of a toxic contaminant that did not have a water quality criterion, and to provide the opportunity for site-specific tuning of the chemical-specific criteria for synergism, antagonism, chemical availability, and exposure situations.

EPA has since expanded its recommended approaches to include a direct measure of biological characteristics (biological criteria) of surface waters. The biological criteria focus on the numbers, types and characteristics of organisms present downstream of a discharge or runoff compared with the numbers, types and characteristics expected based on the aquatic life habitat characteristics. A number of states have developed biological criteria and have been using them in water pollution control programs.

At a 1992 EPA workshop on water quality criteria and standards, EPA representatives revealed that the Agency would soon be releasing a position paper announcing the policy of "Independent Applicability." The June 1992 issue of EPA's "Newsletter Water Quality Criteria & Standards," however, stated that Independent Applicability is EPA's present position, and it is detailed in several documents. That inconsistency notwithstanding, the policy and/or practice of independent applicability and its ramifications for water pollution control in the country truly deserves a thorough examination.

The Problem with Independent Applicability

According to EPA in 1992, the three above-mentioned regulatory approaches for the regulation of toxics would be applicable to all waters, and the approach that was most "sensitive," (most limiting) for a particular waterbody would guide management. This led to many questions about how the policy would handle a situation in which:

- Biological studies of the receiving waters showed healthy and wholesome fish and other aquatic life populations, the same as those that would be expected based on habitat characteristics, and
- Short-term chronic toxicity testing of the waters in the region showed no aquatic life toxicity, but
- Numeric water quality criteria (or standards equivalent to them) were exceeded.

At that time, EPA stated that even under such circumstances, the discharger or source of runoff would have to implement control programs to eliminate the exceedances of the water quality criteria or standards, or change the standards. It was reported to be EPA's position under the policy of independent applicability to require that site-specific water quality criteria or standards be developed in order to justify not complying with EPA's water quality criteria, or more properly, state standards equivalent to those criteria.

It is appropriate to question the appropriateness of requiring dischargers and state regulatory agencies to develop site-specific water quality standards in response to that scenario (i.e., a situation in which it had been shown that there was no aquatic life toxicity in the receiving waters for the discharge/runoff and the populations of aquatic life in the region of expected impact were what would be expected based on habitat characteristics). There have been few attempts to develop site-specific water quality standards as outlined in EPA's Water Quality Criteria Handbook. As a consequence of the state of California Water Resources Control Board's adoption of EPA criteria as state water quality objectives (standards) in April 1991, a number of studies have been undertaken in California in an effort to develop site-specific objectives. More than $300,000 were spent in such effort in the San Francisco Bay area; more than $1.1 million were spent in efforts to develop site-specific criteria/standards for the Santa Ana River in southern California. However, as discussed below, the funds spent in trying to develop site-specific water quality objectives for copper in San

Francisco Bay were unsuccessful in protecting designated beneficial uses of Bay waters from copper toxicity without significant unnecessary expenditures for copper control.

In this example, the development of Water Effect Ratio adjustment of the water quality standard resulted in increasing the copper water quality standard from 2.9 µg/L to 4.9 µg/L. However, San Francisco Bay waters frequently contain from 10 to 15 µg/L total copper without toxicity to the same organisms that were primarily used to develop EPA's criterion for copper. Dissolved copper is also present in some Bay waters at a factor of more than twice the site-specific standard without aquatic life toxicity to the same organisms used to develop the criterion and other sensitive forms of aquatic life.

The failure of the Water Effect Ratio criteria/standard adjustment approach to develop a reliable appropriate criteria/standard reflects the Agency's failure to properly incorporate aquatic chemistry of contaminants into its site-specific criteria/standard development guidance. The original and the February 1994 Water Effect Ratio guidance fail to address one of the most significant causes of chemical specific impacts that result in a chemical contaminant being less toxic than that predicted based on the Agency's site-specific guidance. Chemical forms added to a waterbody from point and non-point source discharges and runoff and those within a waterbody do not necessarily equilibrate with toxic-available forms in the waterbody. This is especially true for particulate forms. Thus, there can be a significant pool of an inert contaminant in a waterbody that is not participating in any Water Effect Ratio adjustment testing. This pool, however, is measured to some undefined extent in the analytical methods as potentially toxic forms of the contaminant.

The Water Effect Ratio adjustment is based on the addition of toxic-available forms under standard laboratory test conditions. Discharges and non-point runoff can add appreciable amounts of inert contaminants even in so-called dissolved forms that do not participate in Water Effect Ratio equilibration reactions. Until the Agency develops an approach for properly considering the aqueous environmental chemistry of chemical contaminants in aquatic systems, it will not be possible to reliably use chemical-specific criteria/standards to regulate potentially toxic-available forms of contaminants without significant unjustified expenditures for contaminant control.

The numeric water quality criteria developed to be conservative best-guess estimates of safe concentrations for worst-case exposure of sensitive organisms were intended to provide guidance ultimately to dischargers on the amount of contaminant control needed to protect designated beneficial uses of receiving waters. Owing to chemical analytical deficiencies, those criteria by and large have not been applied selectively to available-toxic forms of contaminants, but rather have been applied to the total or near-total concentrations of contaminants; this was done with the general understanding in the technical arena that such implementation added yet another degree of conservatism to those values. The origins and nature of the criteria were forgotten when "exceedance of the criteria values" itself became an "adverse impact" deserving of prevention. In truth, those familiar with the original development of the water quality criteria know that the criteria are tools, worst-case or near worst-case estimate indications of potential concerns, not end-points or adverse impacts in and of themselves.

Independent applicability is now beginning to significantly distort the implementation of technically valid, cost-effective approaches for managing water quality in the U.S. An example of such distortion occurs in EPA's National Water Quality Inventory 1994 Report to Congress. EPA informed states, as part of their guidance for developing the National Water Quality Inventory, that they should use an exceedance of a chemical specific criteria/standard as an impaired waterbody. This results in significant amounts of misinformation being presented to Congress and the public on the amount of truly impaired waters in the U.S. that is now influencing public policy in contaminant control.

EPA water quality criteria are useful worst-case guidelines for signaling potential water quality concerns in the absence of more definitive information from appropriate biological/toxicological assessments. However, tools in common use today, including the so-called short-term chronic toxicity tests and a number of the biological criteria, are considerably more reliable in assessing the potential of complex effluents to adversely affect beneficial uses of receiving waters, than the worst-case numeric chemical criteria. It is sadly ironic, therefore, that EPA criteria cannot be recognized as having served their purpose and being now outdated for direct application and superseded by more direct and relevant measures of actual impact. Rather than moving ahead with using more technically valid assessment approaches to provide protection of beneficial uses of receiving waters without unjustified unnecessary controls—the mandated goal—EPA is forcing general compliance with what are typically unnecessarily and unjustifiably restrictive "criteria" and standards equivalent to them.

Some water quality experts have long maintained that dischargers or others who choose not to conduct appropriate site-specific evaluation of the impact of the subject discharge or runoff on receiving water beneficial uses should have the worst-case numeric chemical criteria imposed on them as an administratively simple way to attain conservative water quality protection. However, forcing compliance with unnecessarily restrictive numeric chemical criteria/objectives is not without adverse consequences. In the state of California, enforcement of the numeric chemical criteria-equivalent objectives is leading to the development of National Pollutant Discharge Elimination System (NPDES) point-source and non-point-source runoff limits that can result in significant unnecessary expenditures for contaminant control.

It has taken EPA much longer than originally anticipated to begin to effectively address the control of toxics in U.S. waters. Had these issues been addressed when they could and should have been, in the mid-1970s, a far more technically valid, cost-effective approach for managing toxics could be in place today. At that time, the approach for managing heavy metals-associated toxicity proposed by EPA in 1976 was based largely on toxicity tests, not worst-case numeric chemical criteria. The toxicity test approach evolved from the National Academies' of Science and Engineering, Water Quality Criteria - 1972. A panel of experts convened by the Academies concluded that the toxicity test approach provided a technically valid basis upon which to develop regulations for toxic impacts of heavy metals. There is little justification for EPA to now adopt the independent applicability policy that would force the states to implement the overly protective, worst-case criteria or to spend the substantial resources to develop site-specific water quality standards (objectives) where studies of receiving waters have shown that the designated beneficial uses of potential interest to the public are being protected.

Numeric Chemical Criteria, Toxicity Testing, Biological Criteria

EPA's rationale for the independent applicability policy presented in 1992 contained a number of misleading statements with regard to the nature and technically appropriate use of EPA water quality criteria; the "chemical numeric criteria justification" bias was evident. For example, the statement was made comparing the three components of independent applicability: "chemical criteria are designed to address the effects of specific chemicals over the whole range of species."

While the numeric chemical criteria were developed based on available forms of specific chemicals and have relevance in that context, they are applied to whatever forms of the chemicals are determined in the chemical analytical procedures used. Many chemicals exist in aquatic systems in a variety of chemical forms, only some of which affect aquatic organisms. Since chemical analytical procedures do not, in general, discriminate between available and unavailable forms, the criteria are applied de facto against forms of contaminants that are unavailable/nontoxic.

EPA's October 1993 recommendation for the use of dissolved metals rather than total recoverable metals for implementing ambient water standards is a major step in correcting the gross overly protective approach the Agency adopted in the early 1980s for regulating heavy metals. Dissolved metals will also typically be over-protective because of non-toxic metal complexes and colloidal metal forms. The Agency is, however, persisting with total recoverable metals for protection of sediment quality and in implementing NPDES permits. Both of these approaches are unnecessary and over-protective. Further, the Agency is still using total concentration for other contaminants. Dissolved contaminants coupled with ambient water toxicity tests using sensitive forms of aquatic life and field assessment of bioaccumulation should be used for all contaminants, not just a few heavy metals.

Another significant factor is that EPA criteria were developed for long-term or critical life-stage exposure of organisms; they do not take into account actual exposure durations, patterns or exposure, or period of exposure encountered in natural waters. This is especially important after assessing impacts of contaminants at the edge of the mixing zone. Thus, while EPA criteria were designed to address the effects of specific chemicals, they are not applied/implemented in a manner consistent with their design. Furthermore, the numeric chemical criteria were developed to be protective of selected sensitive species. The criteria are being applied, however, to waterbodies which for reasons other than chemical contaminants do not support such sensitive species.

Bias is also reflected in the description of the whole effluent toxicity testing (WET) provided by EPA, which stated, "WET limits are meant to catch unknown or unmeasured chemicals or synergistic effects, and use a very limited set of species."

WET limits should similarly be viewed as providing an ability to "catch" antagonistic effects (interactions that make chemicals less toxic than expected based on the worst-case criteria developed for available forms of chemical contaminants), and to catch situations in which chemical forms are not toxic/available. This aspect of this evaluation and management tool provides a technically valid avenue by which to develop cost-effective management approaches that focus on those contaminants that can adversely affect water quality while minimizing unnecessary expenditures on unjustified contaminant control. The exposure conditions employed in effluent toxicity testing are typically substantially more rigorous than those that would likely be encountered in a receiving water. While a few species are selected for testing, those selected are from among those identified as being "sensitive" and would be expected to be as sensitive or more sensitive than those that may inhabit the receiving water.

The highly over-protective nature of WET is especially important in implementing TUa (acute toxicity) and TUc (chronic toxicity) NPDES permit requirements. There is little possibility of water column aquatic organisms receiving the same exposure conditions in a mixing zone or at its edge as generated in the standard toxicity tests.

With regard to the third component to be applied, EPA stated, "Biological criteria are meant to catch more subtle imbalances in the whole ecology." Biological criteria developed by EPA and others can be useful in the evaluation of impacts of discharges on beneficial uses of areas of receiving waters. However, to indicate that they can "catch more subtle imbalances in the whole ecology" that can be related to a contaminant discharge as the cause, exaggerates the capabilities of biological criteria in many situations. Biological criteria assess the numbers and types of organisms present at a location compared with what may be expected based on the habitat characteristics. Applied properly, they are an integrator of the wide variety of factors that influence the numbers and types of organisms in a waterbody or area of a waterbody. However, many of the factors that influence the numbers and types of organisms have nothing to do with pollution by chemical contaminants. In addition to habitat characteristics, factors such as flow, disease, competition, biological pollution by invading species, food characteristics and availability, overall trophic status, harvesting of organism (e.g., fishing), seasonal and specific climatic events, and other factors including sampling biases, influence the numbers and types of organisms that may be determined to be present at any location. While various biological assessment approaches have been available for decades, many of the wide variety of factors unrelated to chemical contaminants that control and influence populations present are still poorly understood, unable to be meaningfully quantified, and virtually impossible to reliably study or verify in the field. Even with those limitations, reliable biological assessment studies are costly. Thus, while differences in the numbers and types of organisms found upstream and downstream of a discharge (where habitat types and other characteristics are identical) may be indicative of effects of the discharge, the difference is not sufficient to demonstrate that the cause of the difference is the discharge.

EPA concluded from its three statements of purpose for the three components involved in independent applicability: "Thus the measures are meant to be different, and so should be applied independently." While the measures are different, they are not equally reliable and applicable for assessing the impact of chemical contaminants in discharges or runoff on beneficial uses of the receiving water. The authors agree with the 1992 EPA indication that where the results of the three types of evaluations are seemingly inconsistent, the results should be evaluated in light of their differences to resolve apparent conflicts. However, the authors find the bias regarding the utility and purpose of these evaluation tools articulated by EPA very disturbing.

Key aspects of many of the components of the development and implementation of EPA water quality criteria and toxics control programs that cause them to be generally overly restrictive for meeting the mandate to protect designated beneficial uses of receiving waters are summarized below.

- EPA numeric water quality criteria do not recognize that many contaminants exist in aquatic systems in a variety of chemical forms, only some of which are toxic to aquatic life.
- EPA water quality criteria typically do not adequately consider the aquatic chemistry of a contaminant relative to the contaminant's aquatic toxicology.
- EPA's acute and short-term chronic toxicity tests overestimate the toxicity that would actually occur in the receiving waters, especially near the point of discharge outside the mixing zone.
- The duration of exposure (one-hour average for acute and four-day average for chronic) and frequency of occurrence (once in three years) specifications in EPA criteria are grossly restrictive compared to what is needed to protect the designated beneficial uses of surface waters.

In the 22 years that EPA has been in existence, it has advanced and retreated from a number of applicability policies. From the 1970s until November 1980, EPA stood on the policy of presumptive applicability; EPA water quality criteria were presumed to be applicable to a waterbody unless demonstrated otherwise. The technical water quality community was critical of that policy owing to the worst-case nature of some of the criteria. In the 1980s, with the development of much more strict requirements, especially for priority pollutant potential carcinogens, EPA rescinded its policy of presumptive applicability but indicated that states were to develop numeric chemical water quality standards using the guidance of EPA criteria. By the mid-1980s, however, EPA began to retreat again to the policy of presumptive applicability, albeit unofficially. It did, however, in the early 1990s take steps to recognize the issue of contaminant availability, at least for some of the heavy metals where the Agency acknowledged the possibility of states using the soluble (generally more available) forms of heavy metals as a basis for numeric chemical concentration regulations. Even so, it is well-known that that approach can also be more restrictive than necessary to protect designated beneficial uses of receiving waters and does not address the highly over-protective nature of using total concentrations of contaminants for other potentially toxic-bioaccumulatable chemicals.

Progress that had been made toward realistic assessments of potential impacts of available forms and protection of beneficial uses of receiving waters of the 1980s faded in 1992 when EPA adopted a policy that would require that all states without numeric water quality standards adopt the generally worst-case EPA water quality criteria for toxic chemicals as enforceable standards. As discussed, the move toward independent applicability increases the likelihood that overly restrictive contaminant control programs will be required, and at substantially greater costs than would be necessary to provide protection of designated beneficial uses of receiving waters.

This paper is the first of a two-part series. Next issue: The Inappropriateness of Using Independent Applicability to Regulate Stormwater Discharges. ❑